

07-13-00

1c490 U.S. PTO

09/19/00

07/12/00

Practitioner's Docket No. 00656

PATENT

Preliminary Classification:

Proposed Class:

Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P. § 601, 7th ed.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): Dong-il Cho

WARNING: 37 C.F.R. § 1.41(a)(1) points out:

"(a) A patent is applied for in the name or names of the actual inventor or inventors.

"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(f) is filed supplying or changing the name or names of the inventor or inventors."

For (title): Silicon Etching Apparatus Using XeF_2

CERTIFICATION UNDER 37 C.F.R. § 1.10*

(Express Mail label number is mandatory.)

(Express Mail certification is optional.)

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date July 12, 2000 in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EL197553501US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Amy Miles

(type or print name of person mailing paper)

Amy Miles

Signature of person mailing paper

WARNING: Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

*WARNING: Each paper or fee filed by "Express Mail" must have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).

"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will not be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

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1. Type of Application

This new application is for a(n)

(check one applicable item below)

☒ Original (nonprovisional)

☐ Design

☐ Plant

WARNING: Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. § 371(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.

WARNING: Do not use this transmittal for the filing of a provisional application.

NOTE: If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.

☐ Divisional.

☐ Continuation.

☐ Continuation-in-part (C-I-P).

2. Benefit of Prior U.S. Application(s) (35 U.S.C. §§ 119(e), 120, or 121)

NOTE: A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending International applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending International application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. § 112. Each prior application must also be:

(i) An International application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America; or

(ii) Complete as set forth in § 1.51(b); or

(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or

(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(f) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

WARNING: If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120, 121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

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WARNING: When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application must be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).

- ☐ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. Papers Enclosed

A. Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

- 7 Pages of specification
1 Pages of claims
5 Sheets of drawing

WARNING: DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. § 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).

NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (5/8 inch) down from the top of the page . . ." 37 C.F.R. § 1.84(c)).

(complete the following, if applicable)

- ☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).
- ☒ formal
- ☐ Informal

B. Other Papers Enclosed

- 2 Pages of declaration and power of attorney
1 Pages of abstract
 _____ Other

4. Additional papers enclosed

- ☐ Amendment to claims
- ☐ Cancel in this applications claims _____ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
- ☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)
- ☐ Preliminary Amendment
- ☐ Information Disclosure Statement (37 C.F.R. § 1.98)
- ☐ Form PTO-1449 (PTO/SB/08A and 08B)
- ☐ Citations

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- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

5. Declaration or oath (including power of attorney)

NOTE: A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)-(3).

NOTE: A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).

NOTE: "The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.62, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(f) is filed supplying or changing the name or names of the inventor or inventors." 37 C.F.R. § 1.41(a)(1).

☒ Enclosed
Executed by

(check all applicable boxes)

☒ Inventor(s).

- ☐ legal representative of inventor(s).
37 C.F.R. §§ 1.42 or 1.43.
- ☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.

- ☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F.R. § 1.47 is also attached. See item 13 below for fee.

☐ Not Enclosed.

NOTE: Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

- ☐ Application is made by a person authorized under 37 C.F.R. § 1.41(c) on behalf of all the above named inventor(s).

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(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e) can be filed subsequently).

- ☐ Showing that the filing is authorized.
(not required unless called into question. 37 C.F.R. § 1.41(d))

6. Inventorship Statement

WARNING: If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

☒ The same.

or

- ☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,
- ☐ Is submitted.
- ☐ Will be submitted.

7. Language

NOTE: An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of \$130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).

- ☒ English
- ☐ Non-English
- ☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

8. Assignment

- ☐ An assignment of the invention to _____
- ☐ Is attached. A separate ☐ "COVER SHEET FOR: ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.
- ☐ Will follow.

NOTE: "If an assignment is submitted with a new application, send two separate letters—one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

WARNING: A newly executed "CERTIFICATE UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.

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9. Certified Copy

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

- ☐ is (are) attached.
☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. § 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10. Fee Calculation (37 C.F.R. § 1.16)

A. ☒ Regular application

CLAIMS AS FILED			
Number filed	Number Extra	Rate	Basic Fee 37 C.F.R. § 1.16(a) \$760.00
Total Claims (37 C.F.R. § 1.16(c))	- 20 =	x \$ 18.00	
Independent Claims (37 C.F.R. § 1.16(b))	- 3 =	x \$ 78.00	
Multiple dependent claim(s), If any (37 C.F.R. § 1.16(d))		+ \$260.00	

- ☐ Amendment cancelling extra claims is enclosed.
☐ Amendment deleting multiple-dependencies is enclosed.
☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(d).

Filing Fee Calculation \$ 690.00

B. ☐ Design application
(\$310.00—37 C.F.R. § 1.16(f))

Filing Fee Calculation \$

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- C. ☐ Plant application
(\$480.00—37 C.F.R. § 1.16(g))

Filing fee calculation

\$ _____

11. Small Entity Statement(s)

- ☒ Statement(s) that this is a filing by a small entity under 37 C.F.R. § 1.9 and 1.27 is (are) attached.

WARNING: "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. § 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).

WARNING: "Small entity status must not be established when the person or persons signing the . . . statement can unequivocally make the required self-certification." M.P.E.P., § 509.03, 6th ed., rev. 2, July 1996 (emphasis added).

(complete the following, if applicable)

- ☐ Status as a small entity was claimed in prior application
_____ / _____, filed on _____, from which benefit
is being claimed for this application under:

35 U.S.C. § ☐ 119(e),
☐ 120,
☐ 121,
☐ 365(c),

and which status as a small entity is still proper and desired.

- ☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of A, B or C above)

\$ 345.00

NOTE: Any excess of the full fee paid will be refunded if small entity status is established and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136, 37 C.F.R. § 1.28(a).

12. Request for International-Type Search (37 C.F.R. § 1.104(d))

(complete, if applicable)

- ☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

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13. Fee Payment Being Made at This Time

☐ Not Enclosed

☐ No filing fee is to be paid at this time.

(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)

☒ Enclosed

☒ Filing fee

\$ 345.00

☐ Recording assignment

(\$40.00; 37 C.F.R. § 1.21(h))

(See attached "COVER SHEET FOR
ASSIGNMENT ACCOMPANYING NEW
APPLICATION".)

\$ _____

☐ Petition fee for filing by other than all the
inventors or person on behalf of the inventor
where inventor refused to sign or cannot be
reached

(\$130.00; 37 C.F.R. §§ 1.47 and 1.17(l))

\$ _____

☐ For processing an application with a
specification in

a non-English language

(\$130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k))

\$ _____

☐ Processing and retention fee

(\$130.00; 37 C.F.R. §§ 1.53(d) and 1.21(l))

\$ _____

☐ Fee for international-type search report

(\$40.00; 37 C.F.R. § 1.21(e))

\$ _____

NOTE: 37 C.F.R. § 1.21(l) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. §§ 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from notification under § 53(f).

Total fees enclosed

\$ 345.00

14. Method of Payment of Fees

☒ Check in the amount of \$ 345.00

☐ Charge Account No. _____ in the amount of
\$ _____

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 C.F.R. § 1.22(b).

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15. Authorization to Charge Additional Fees

WARNING: If no fees are to be paid on filing, the following items should not be completed.

WARNING: Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.

- ☒ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 08-1500:

☒ 37 C.F.R. § 1.16(a), (f) or (g) (filing fees)

☒ 37 C.F.R. § 1.16(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

☒ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☒ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a)).

☒ 37 C.F.R. § 1.17 (application processing fees)

NOTE: ". . . A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

☐ 37 C.F.R. § 1.18 (Issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. § 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . the issue fee. . . ." From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

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16. Instructions as to Overpayment

NOTE: "... Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

☒ Credit Account No. 08-1500

☐ Refund

Reg. No. 19,224

Tel. No. (918) 587-2000

Customer No. 24,118



SIGNATURE OF PRACTITIONER

Paul H. Johnson

(type or print name of attorney)

228 West 17th Place

P.O. Address

Tulsa, OK 74119

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☐ Incorporation by reference of added pages

(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)

- ☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added _____

- ☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added _____

- ☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added _____

- ☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added _____

☒ Statement Where No Further Pages Added

(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)

- ☒ This transmittal ends with this page.

Applicant or Patentee: **CHO, DONG-IL**

Attorney's Docket

Serial or Patent No:

No. SAM435/00656

Filed or Issued:

For:

SILICON ETCHING APPARATUS USING XeF₆

**VERIFIED STATEMENT (DECLARATION)
CLAIMING SMALL ENTITY STATUS
[37 CFR SECTION 1.9 (f) and SECTION 1.27 (b)]
INDEPENDENT INVENTOR**

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9 (c) for purposes of paying reduced fees under Section 41 (a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled:

SILICON ETCHING APPARATUS USING XeF₆

described in:

- ☒ the specification filed herewith.
☐ Application Serial No. _____ filed _____.
☐ Patent No. _____ issued _____.

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9 (c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9 (d) or a nonprofit organization under 37 CFR 1.9 (e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey or license any rights in the invention is listed below:

- ☒ no such person, concern, or organization
☐ persons, concerns or organizations listed below*

* NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. [37 CFR 1.27].

FULL NAME:

☒ INDIVIDUAL

ADDRESS:

☐ SMALL BUSINESS CONCERN

☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the

09614785, 0712010

July, 12, 2000
Date

[illegible]

SILICON ETCHING APPARATUS USING XeF_2

Technical Field

5 The present invention generally relates to a silicon etching apparatus and, more particularly, to a silicon etching apparatus using XeF_2 .

Background Art

There are a variety of etching reagents used for silicon bulk etching to accurate dimensions, ranging from a liquid type etchant such as ethylene diamine pyrocatechol
10 (EDP) and KOH to high energy plasma type etchants based on Cl_2 or SF_6 gases. These etching reagents may provide much flexibility and controllability in the manufacture of accurately defined microstructures but have a limitation on use due to the limited selectivity with respect to general materials such as photoresist or oxide commonly used as a masking layer in the etching process.

15 Xenon difluoride (hereinafter, referred to as " XeF_2 ") is a silicon etching reagent in a dry gas phase which presents several advantages over the above silicon etching reagents. XeF_2 is a white solid at the room temperature under the atmospheric pressure and sublimates at the room temperature (25 °C) under a pressure less than 3.8 Torr. An etching method using sublimated XeF_2 has a high selectivity to photoresist, oxide or aluminum
20 layers and enables etching silicon in the gas phase, thus preventing the resulting structure adhering to the substrate. Also, such an etching method enables rapid etching of the bottom surface of a large-sized silicon structure due to an isotropic etching characteristic and a high etching rate of several $\mu\text{m}/\text{min}$. This etching method using XeF_2 alone neither forms a polymer layer nor leaves other contaminants on the etched surfaces.

25 A conventional silicon etching apparatus using XeF_2 is composed of a loading

chamber for loading XeF_2 , an expansion chamber for collecting sublimated XeF_2 gas, and an etching chamber for performing an etching process.

Several conventional XeF_2 -based silicon etching apparatuses of the above structure involve some problems as follows:

5 First, during the silicon etching process using XeF_2 , air moisture existing in the etching apparatus associates fluorine with hydrogen to form hydrofluoric acid(HF), which may damage a silicon oxide layer used as a profile protecting layer of the silicon. It is thus required to dehumidify the inside of the apparatus completely prior to the XeF_2 -based silicon etching process.

10 Second, the XeF_2 -based etching may not be performed uniformly even on a full silicon wafer, because the etching occurs further in a portion having a denser XeF_2 gas on the surface of the silicon wafer than a portion with less dense XeF_2 gas. So, the etching uniformity depends on how the XeF_2 gas is uniformly distributed all over the surface of the target wafer.

15 Third, sublimation of the residual XeF_2 in the loading chamber may be problematic. It is general that the remaining XeF_2 after the etching process is reserved in the loading chamber for future uses, with the loading chamber maintained under vacuum according to the vacuum-based maintenance and control method. However, XeF_2 continuously sublimates in the loading chamber at the room temperature under a pressure less than 3.8
20 Torr. Such a sublimation of XeF_2 causes unnecessary consumption of an expensive material and association of the sublimated XeF_2 gas with air moisture to corrode the chamber and other connected, annexed parts.

Finally, it is hard to measure the amount of the residual XeF_2 in the loading chamber. The conventional XeF_2 -based silicon etching apparatus has a window on the loading

chamber for visual checking the amount of the residual XeF_2 in the chamber after the completion of the etching process. Such a visual check is a troublesome method and sometimes impossible when HF is formed from the sublimated XeF_2 associating with air moisture to corrode the window of the loading chamber cloudy.

5 Disclosure of Invention

The present invention is to solve the problems with the conventional XeF_2 -based silicon etching apparatus and it is therefore an object of the present invention to provide a XeF_2 -based silicon etching apparatus capable of eliminating the internal air moisture to minimize damages on a silicon oxide layer.

10 It is another object of the present invention to provide a XeF_2 -based silicon etching apparatus enabling uniform etching of a full silicon wafer.

If is further another object of the present invention to provide a XeF_2 -based silicon etching apparatus capable of preventing sublimation of the residual XeF_2 in a loading chamber.

15 It is still another object of the present invention to provide a XeF_2 -based silicon etching apparatus capable of measuring the amount of the residual XeF_2 in the loading chamber.

To achieve the above objects, there is provided a silicon etching apparatus using XeF_2 including: a basic structure composed of a loading chamber for loading XeF_2 , an
20 expansion chamber for collecting sublimated XeF_2 gas, and an etching chamber for performing an etching process; and a means for injecting nitrogen prior to the etching process to eliminate air moisture in the apparatus and thus preventing the formation of HF.

The silicon etching apparatus using XeF_2 further includes an injector having a predefined shape provided in the etching chamber for uniformly injecting the XeF_2 gas on

the surface of a wafer.

The silicon etching apparatus using XeF_2 further includes a feedback controller for feedback controlling the internal pressure of the loading chamber in order to prevent sublimation of the residual XeF_2 in the loading chamber.

- 5 The silicon etching apparatus using XeF_2 further includes a weight scale for measuring the weight of remaining XeF_2 in the loading chamber.

Brief Description of Drawings

Fig. 1 is a schematic diagram of a XeF_2 -based silicon etching apparatus according to an embodiment of the present invention;

- 10 Figs. 2 and 3 show examples of a XeF_2 injector in an etching chamber contrived according to the present invention;

Fig. 4 is a schematic diagram of a feedback controller for maintaining the pressure of a loading chamber in the XeF_2 -based silicon etching apparatus of the present invention; and

- 15 Fig. 5 is a diagram of a weight scale in use, provided in the loading chamber of the XeF_2 -based silicon etching apparatus according to the present invention.

Preferred Embodiment for Carrying out the Invention

- Reference will now be made in detail to a XeF_2 -based silicon etching apparatus according to the present invention, examples of which are illustrated in the accompanying
20 drawings.

Fig. 1 is a schematic diagram of a XeF_2 -based silicon etching apparatus according to an embodiment of the present invention.

As shown in Fig. 1, the XeF_2 -based silicon etching apparatus of the present invention comprises a loading chamber 11, an expansion chamber 12, an etching chamber

13 and, further, a nitrogen injector for purging with nitrogen prior to the etching process to eliminate air moisture existing in the apparatus and thus, to prevent the formation of HF. Removal of HF raises the selectivity of silicon to masking oxide layers to more than 2000:1 to reduce damage to the masking oxide layers profile, enabling a long etching process.

5 The XeF_2 -based silicon etching apparatus of the present invention further comprises a XeF_2 injector having a predefined shape provided in the etching chamber 13 in order to provide uniformity in etching a full silicon wafer.

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10 Figs. 2 and 3 show examples of a XeF_2 injector in the etching chamber contrived according to the present invention. Figs. 2a and 3a are bottom views of the XeF_2 injector; Figs. 2b and 3b are side views; Figs. 2c and 3c are perspective views; and Figs. 2d and 3d show the XeF_2 injector during the etching step. As shown in Figs. 2 and 3, the XeF_2 injector of the present invention is contrived to uniformly inject XeF_2 from the top to the bottom in the etching chamber 13, thus creating a uniform downward viscous laminar motion of the XeF_2 gas. This is because the XeF_2 whose molecular weight is 169.29 g/mol is heavier than air (dry air, 28.96 g/mol) or nitrogen (28.0134 g/mol), and because in this
15 low pressure environment the downward flow becomes highly viscous.

20 The XeF_2 -based silicon etching apparatus of the present invention further comprises a means for maintaining the pressure of the loading chamber above 3.8 Torr and lower than the atmospheric pressure in order to prevent sublimation of the residual XeF_2 in the loading chamber which the etching apparatus is not use. With the internal pressure of the loading chamber lower than the atmospheric pressure, the cover of the loading chamber is maintained closed. In order to open the cover, the internal pressure of the loading chamber is increased to a pressure higher than the atmosphere pressure.

Fig. 4 is a schematic diagram of a feedback controller for maintaining the pressure

of the loading chamber 11 in the XeF_2 -based silicon etching apparatus of the present invention. As shown in Fig. 4, the feedback controller maintains, by way of feedback control, the internal pressure of the loading chamber 11 to a constant pressure between 3.8 Torr, which is the sublimation pressure of XeF_2 , and the atmospheric pressure. For this, the apparatus further comprises a pressure sensor 41 in the loading chamber 11 and uses a pressure gauge 42 to measure the internal pressure of the loading chamber 11, subtracting the measured pressure value from a reference pressure between the sublimation pressure of XeF_2 and the atmospheric pressure for feedback.

The XeF_2 -based silicon etching apparatus of the present invention further comprises a weight scale provided in the loading chamber 11 in order to measure the amount of the residual XeF_2 in the loading chamber 11.

Fig. 5 is a diagram showing the weight scale in use, provided in the loading chamber of the XeF_2 -based silicon etching apparatus according to the present invention. A container 51 filled with XeF_2 is placed on the weight scale 52 in the loading chamber 11 and the chamber 11 is made airtight. With the container 51 open, the weight of XeF_2 plus the container is measured, while measuring the weight of the residual XeF_2 in the loading chamber at any time during the etching step, to estimate the remaining time for performing the etching step with the residual XeF_2 .

As described in the above, the XeF_2 -based silicon etching apparatus of the present invention eliminates the inner air moisture to minimize a damage to an oxide layer and further comprises (a) the XeF_2 injector having a predefined shape in the etching chamber to enable uniform etching of a full silicon wafer, (b) the feedback controller for feedback controlling the pressure of the loading chamber above the sublimation pressure of XeF_2 and below the atmospheric pressure to prevent sublimation of the residual XeF_2 in the loading

WHAT IS CLAIMED IS:

1. A silicon etching apparatus using XeF_2 , comprising:
a basic structure composed of a loading chamber for loading XeF_2 , an expansion
5 chamber for collecting sublimated XeF_2 gas, and an etching chamber for performing an
etching process; and
a means for injecting nitrogen prior to the etching process to eliminate air moisture
in the apparatus and thus preventing the formation of HF.
- 10 2. The silicon etching apparatus using XeF_2 as claimed in claim 1, further
comprising an injector having a predefined shape provided in the etching chamber for
uniformly injecting the XeF_2 gas on the surface of a wafer with a viscous laminar downflow.
3. The silicon etching apparatus using XeF_2 as claimed in claim 1, further
15 comprising a means for feedback controlling the internal pressure of the loading chamber.
4. The silicon etching apparatus using XeF_2 as claimed in claim 1, further
comprising a means for measuring the weight of XeF_2 in the loading chamber.

ABSTRACT

The silicon etching apparatus using XeF_2 includes: a basic structure composed of a loading chamber for loading XeF_2 , an expansion chamber for collecting sublimated XeF_2 gas, and an etching chamber for performing an etching process; and a means for injecting
5 nitrogen prior to the etching process to eliminate air moisture in the apparatus and thus preventing the formation of HF. The silicon etching apparatus using XeF_2 further includes: an injector having a predefined shape provided in the etching chamber for uniformly injecting the XeF_2 gas downward on to surface of a wafer; a feedback controller for feedback controlling the internal pressure of the loading chamber in order to prevent
10 sublimation of the residual XeF_2 in the loading chamber; and a weight scale for measuring the weight of XeF_2 in the loading chamber.

Fig. 1

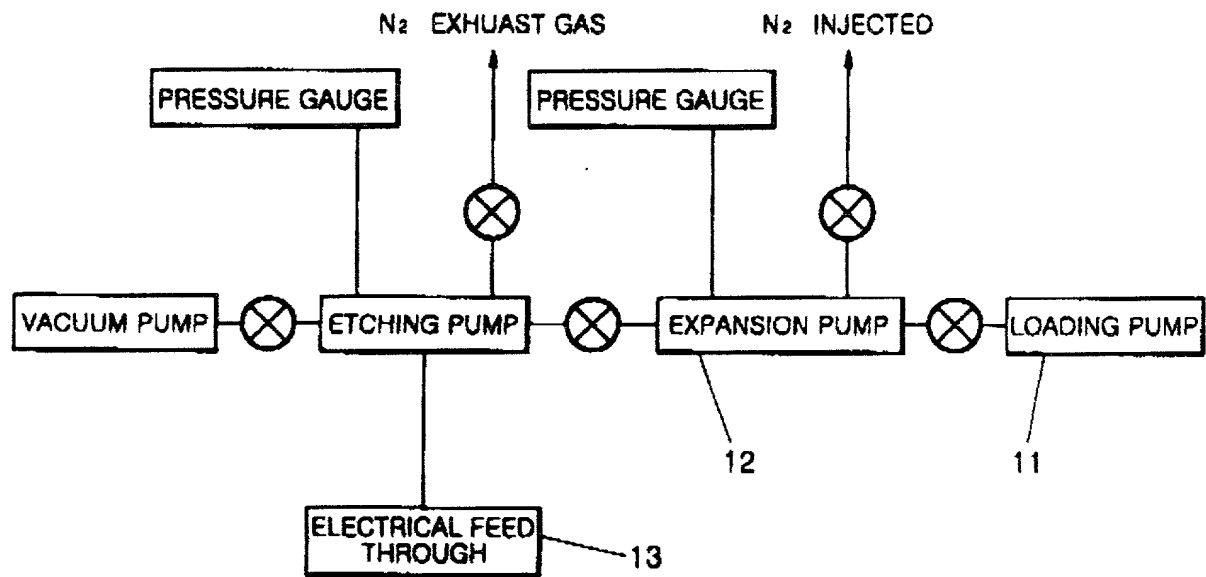
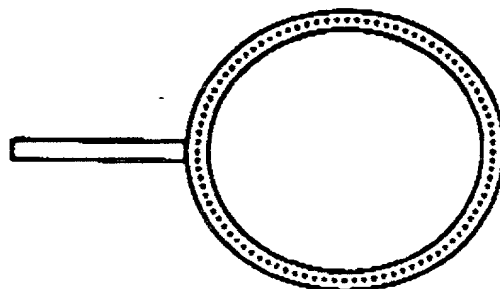


Fig. 2a



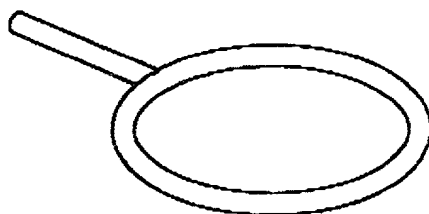
BOTTOM VIEW

Fig. 2b



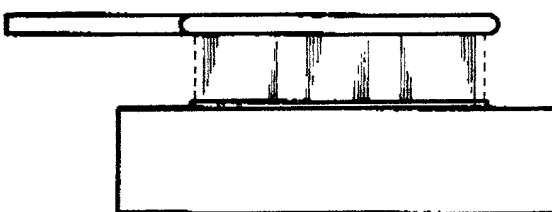
SIDE VIEW

Fig. 2c



PERSPECTIVE VIEW

Fig. 2d

XeF₂ INJECTOR DURING THE ETCHING STEP

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Fig. 3a

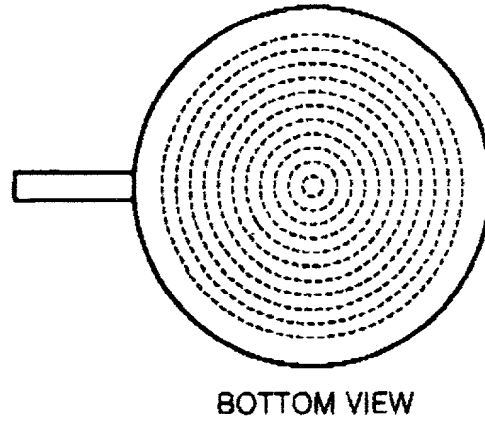
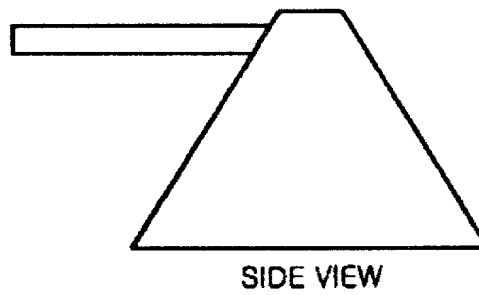
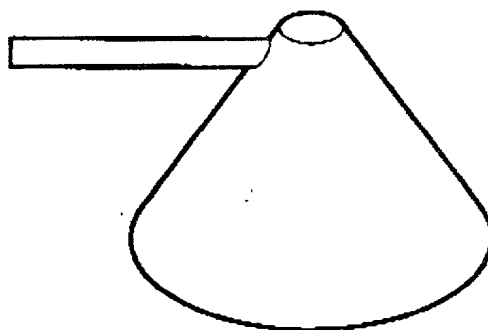


Fig. 3b



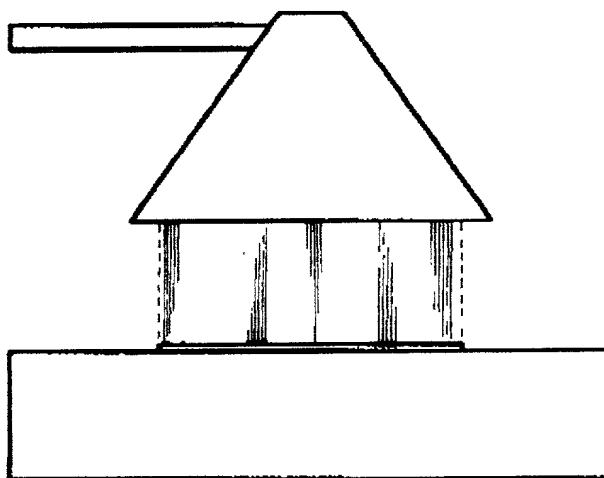
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Fig. 3c



PERSPECTIVE VIEW

Fig. 3d

XeF₂ INJECTOR DURING THE ETCHING STEP

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Fig. 4

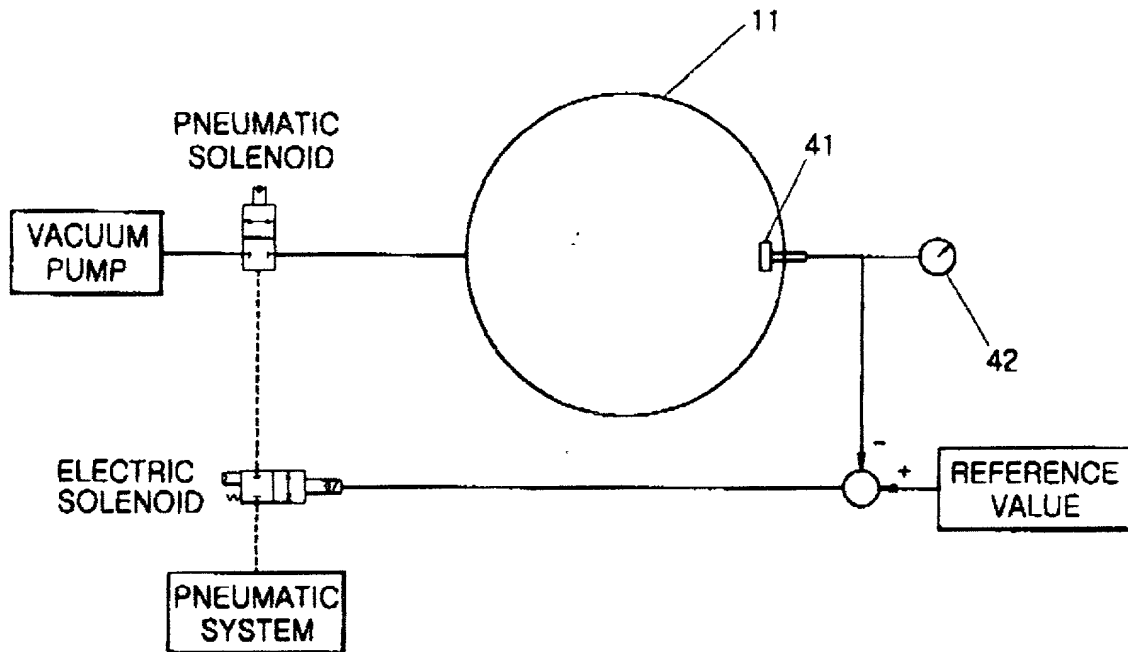
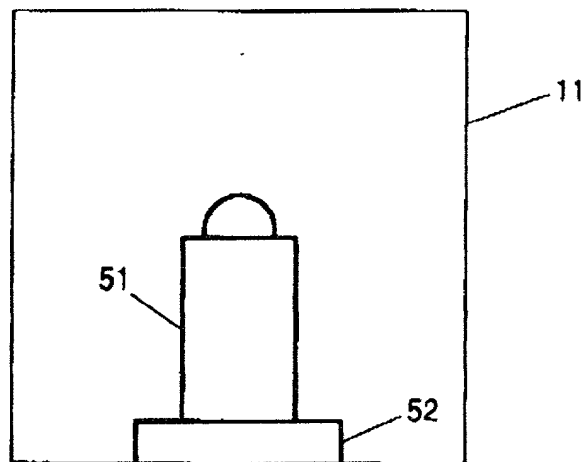


Fig. 5



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COMBINED DECLARATION AND POWER OF ATTORNEY
(Original, Design, National Stage Of PCT, Supplemental)

As the below named inventor, I hereby declare that:

This declaration is of the following type:

- ☒ original
☐ design
☐ national stage of PCT
☐ supplemental

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SILICON ETCHING APPARATUS USING XeF₄

the specification of which:

(a) ☒ is attached hereto

(b) ☐ was filed on _____ as _____ or ☐ Express Mail No., as Serial No. not yet known _____ and was amended by Preliminary amendment

(c) ☐ was described and claimed in PCT International Application No. _____ filed on _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by the Preliminary Amendment attached hereto.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

☐ In compliance with this duty there is attached an information disclosure statement 37 CFR 1.97.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(d) ☒ no such applications have been filed.

(e) ☐ such applications have been filed as follows:

COUNTRY	APPLICATION NUMBER	DATE OF FILING	PRIORITY CLAIMED UNDER 37 USC 119
_____	_____	_____	__YES __NO

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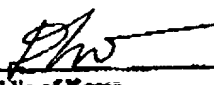
As the below named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: Paul H. Johnson, Reg. No. 19,224 and/or Mark G. Kachigian Reg. No. 32,840 of the firm of HEAD, JOHNSON & KACHIGIAN 228 West 17th Place, Tulsa, Oklahoma 74119, Telephone Number (918) 587-2000, members of the Bar of the State of Oklahoma, and Robert R. Keegan, Reg. No. 18,614 and/or Trent C. Keisling, Reg. No. 36,565 of Head, Johnson & Kachigian, 112 West Center Street, Suite 230, Fayetteville, Arkansas, and Martin G. Ozinga, Reg. No. 44,992 and/or Daniel S. Hodgins, Reg. No. 31,026 of the firm of Head, Johnson & Kachigian, 204 North Robinson, Suite 3030, City Place Building, 30th Floor, Oklahoma City, Oklahoma 73102, Telephone Number (405) 236-4000, member of the Bar of the State of Oklahoma, to prosecute this application to register, to transact all business in the Patent and Trademark Office in connection therewith, and to receive the Letter Patent Document, if issued.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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